

Exploring Greenland: Science and Technology in Cold War Settings

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Volume 33, numéro 2, 2010

Comparative Issues in the History of Circumpolar Science and Technology

URI : <https://id.erudit.org/iderudit/1006149ar>

DOI : <https://doi.org/10.7202/1006149ar>

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Éditeur(s)

CSTHA/AHSTC

ISSN

0829-2507 (imprimé)

1918-7750 (numérique)

[Découvrir la revue](#)

Citer cet article

Heymann, M., Knudsen, H., Lolck, M. L., Nielsen, H., Nielsen, K. H. & Ries, C. J. (2010). Exploring Greenland: Science and Technology in Cold War Settings. *Scientia Canadensis*, 33(2), 11–42. <https://doi.org/10.7202/1006149ar>

Résumé de l'article

Cet article s'intéresse à un aspect méconnu de l'histoire des sciences de la Guerre Froide : le développement au Groenland d'activités de recherche dans les sciences physiques de l'environnement et les sciences et technologies nucléaires. Lors de la période d'après-guerre, l'exploration scientifique des régions polaires est devenue un élément stratégique important dans les politiques de défense américaine et soviétique. Les champs de recherche géophysique tels que la météorologie, la géologie, la sismologie et l'océanographie ont particulièrement profité de l'intérêt militaire. Si le Danemark conserve sa souveraineté formelle sur le Groenland, les activités de recherche se voient toutefois fortement dominées par les intérêts de l'armée américaine. Cet article cherche à faire le point sur l'état limité des connaissances en matière d'activités de recherche en sciences physiques de l'environnement au Groenland, et de leur intrication avec les intérêts militaires, géopolitiques et coloniaux à la fois des États-Unis et du Danemark. Nous dépeignons la recherche géophysique au Groenland durant la Guerre Froide comme une entreprise coloniale multidimensionnelle. À l'ère de la décolonisation suivant la Seconde Guerre mondiale, le Groenland, une colonie danoise, se voit également colonisé par l'armée américaine. Du coup, au moment où émerge un internationalisme scientifique, l'armée américaine «colonise» la recherche géophysique dans l'Arctique, qui devient de plus en plus soumise aux directives, à la culture, et aux règles militaires.

Exploring Greenland: Science and Technology in Cold War Settings¹

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Abstract: This paper explores a vacant spot in the Cold War history of science: the development of research activities in the physical environmental sciences and in nuclear science and technology in Greenland. In the post-war period, scientific exploration of the polar areas became a strategically important element in American and Soviet defence policy. Particularly geophysical fields like meteorology, geology, seismology, oceanography, and others profited greatly from military interest. While Denmark maintained formal sovereignty over Greenland, research activities were strongly dominated by U.S. military interests. This paper sets out to summarize the limited current state of knowledge about activities in the environmental physical sciences in Greenland and their entanglement with military, geopolitical, and colonial interests of both the USA and Denmark. We describe geophysical research in the Cold War in Greenland as a multidimensional colonial endeavour. In a period of decolonization after World War II, Greenland, being a Danish colony, became additionally colonized by the American military. Concurrently, in a period of emerging scientific internationalism, the U.S. military “colonized” geophysical research in the Arctic, which increasingly became subject to military directions, culture, and rules.

Résumé : Cet article s’intéresse à un aspect méconnu de l’histoire des sciences de la Guerre Froide : le développement au Groenland d’activités de recherche dans les sciences physiques de l’environnement et les sciences et technologies nucléaires. Lors de la période d’après-guerre, l’exploration scientifique des régions polaires est devenue un élément stratégique important dans les politiques de défense américaine et soviétique. Les champs de recherche géophysique tels que la météorologie, la géologie, la sismologie et l’océanographie ont particulièrement profité de l’intérêt militaire. Si le Danemark conserve sa souveraineté formelle sur le Groenland, les activités de recherche se voient toutefois fortement dominées par les intérêts de l’armée américaine. Cet article cherche à faire le point sur l’état limité des connaissances en matière d’activités de recherche en sciences physiques de

1. This paper was prepared in the new collaborative Danish-American project “Exploring Greenland: Science and Technology in Cold War Settings” led by Aarhus University. We are deeply grateful for the advice and strong support of Ronald E. Doel and Kristine C. Harper. We also thank Thorsten Borring-Olesen, Poul Villaume, Peer Henrik Hansen, Zuoyue Wang, Robert Marc Friedman, Sverker Sörlin, and John Krige for their helpful and constructive comments and the Carlsberg Foundation for funding the project.

l'environnement au Groenland, et de leur intrication avec les intérêts militaires, géopolitiques et coloniaux à la fois des États-Unis et du Danemark. Nous dépeignons la recherche géophysique au Groenland durant la Guerre Froide comme une entreprise coloniale multidimensionnelle. À l'ère de la décolonisation suivant la Seconde Guerre mondiale, le Groenland, une colonie danoise, se voit également colonisé par l'armée américaine. Du coup, au moment où émerge un internationalisme scientifique, l'armée américaine «colonise» la recherche géophysique dans l'Arctique, qui devient de plus en plus soumise aux directives, à la culture, et aux règles militaires.

Introduction

Cold War science and technology have gained considerable attention in recent years. During and after World War II, the links between science, technology, and foreign policy tightened considerably and spurred an enormous expansion of military funded research, particularly in the USA. The U.S. government aimed at projecting and consolidating its power in the international domain. International relations between scientists and scientific bodies provided a pre-established platform for the extension of political control by integrating science and technology into foreign affairs.² In Europe, science and technology played an important role not only in the reconstruction of European nation states and the forging of supranational organizations and identities, but also as symbols of modernity and a new, more rational world order.³

During and after World War II, U.S. foreign and defence policy interests led to the creation of numerous new, permanent institutions designed to assess or manipulate international science to benefit U.S. national security. By 1950, the Office of Scientific Intelligence of the Central Intelligence Agency (CIA), the Science Advisor's office within the Department of State, and the Research and Development Board (RDB) of the Department of Defense had emerged along with a large number of other more specialized bodies. These bodies created, stimulated, or

2. R.E. Doel, "Scientists as Policymakers, Advisors, and Intelligence Agents: Linking Diplomatic History with the History of Science," in *The Historiography of Contemporary Science and Technology*, ed. T. Söderqvist (London: Harwood Academic Press, 1997), 33-62; R.E. Doel and Z. Wang, "Science and Technology," in *Encyclopedia of American Foreign Policy*, eds. A. DeConde, R.D. Burns and F. Logevall (New York: Macmillan, 2001), 443-59; J. Krige, *American Hegemony and the Postwar Reconstruction of Science in Europe* (Cambridge, MA: MIT, 2006); J. Manzione, "'Amusing and Amazing and Practical and Military': The Legacy of Scientific Internationalism in American Foreign Policy, 1945-1963," *Diplomatic History* 24, 1 (2000): 21-55.

3. J. Krige, "The Politics of European Scientific Collaboration," in *Companion to Science in the Twentieth Century*, eds. J. Krige and D. Pestre (London: Routledge, 1997); Krige, *American Hegemony*; J. Schot, T. Misa and R. Oldenziel, eds., *Tensions of Europe: The Role of Technology in the Making of Europe*, Special issue of *History and Technology* 21, 1 (2005): 1-139.

controlled a large share of research activities in the Cold War period in the applied as well as in the basic sciences. Among the many scientific fields profiting from heavy governmental and military funding, the physical environmental sciences figured very prominently. In the pre-war era fields like cartography, weather forecasting, and geological explorations had long been staples of government patronage in the USA as well as in Europe. They all served the state's need for accurate and useful knowledge of its dominion and either the expansion or defence of a nation's boundaries. The Cold War added fields like geophysics, oceanography, seismology, and similar fields to the state's arsenal of scientific interests.⁴ Already twenty-four months after World War II ended, the RDB succeeded in making the physical environmental sciences (what the U.S. military simply termed "the environmental sciences") a high national priority. Military funding for the earth sciences skyrocketed to twenty-five million dollars, a sum just behind that provided to physics.⁵

The earth sciences expanded dramatically during the first decades of the Cold War. A Pentagon document from 1961 emphasized the "vital interest in the environmental sciences since the military services must have an understanding of, and an ability to predict and even to control the environment in which it is required to operate."⁶ Geographer John Cloud concluded that "for all the earth science disciplines, the postwar decades were probably the most productive periods in their histories."⁷ A schematic from the 1948 annual report of the RDB's Committee on the Geophysical Sciences defined the priority research fields for the years to come, highlighting their military importance. This list included fields like cartography and geodesy providing solutions to missile ranging and guidance problems, geology to explore strategic minerals and develop "terrain intelligence," meteorology for military weather forecasting and air operations, upper atmosphere research to support guided missile

4. M.A. Dennis, "Secrecy and Science Revisited: From Politics to Historical Practice and Back," in *The Historiography of Modern Science, Technology, and Medicine*, eds. R.E. Doel and T. Söderqvist (London: Routledge, 2006), 172-84; P.N. Edwards, *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming* (Cambridge, MA: MIT Press, 2010).

5. R.E. Doel, "What's the Place for the Physical Environmental Sciences in Environmental History?" manuscript; we use in this paper the original English version of the manuscript; a French translation was published as "Quelle place pour les sciences de l'environnement physique dans l'histoire environnementale?," *Revue d'Histoire Moderne et Contemporaine* 56, 4 (2009): 137-164.

6. R.E. Doel, "Constituting the Postwar Earth Sciences: The Military's Influence on the Environmental Sciences in the USA after 1945," *Social Studies of Science* 33, 5 (2003): 636.

7. J. Cloud, "Special Guest-Edited Issue on the Earth Sciences in the Cold War—Introduction," *Social Studies of Science* 33, 5 (2003): 629.

design and long range communications, or seismology to improve the shock protection of surface and subsurface installations.⁸

The U.S. military was particularly interested in the Arctic. Alaska shared a common boundary with Siberia along the Bering Sea, and the shortest route for Soviet bombers targeting U.S. cities lay across the pole and vice versa. The confrontation of the new superpowers had changed the geopolitical role of the Arctic profoundly and made it “one of the most important areas in the world [...] The next war would be fought in, on, and under the Arctic.”⁹ But the Arctic was a largely unknown region. In this situation the geophysical science represented a crucial gateway to the Arctic in two different ways. First, they had to provide the knowledge needed for military control and activities in such inhospitable conditions. Second, scientific activities appeared a soft way to gain power and control without the use of military force. Greenland represented a particularly important land mass in the Arctic and became a focus of geophysical research funded by the U.S. military. But Cold War research in Greenland has to date not been investigated comprehensively.

In the following sections we will discuss the military and scientific challenges in the Arctic and give an overview on the state of knowledge of scientific activities in Greenland. We cover nuclear science and technology, geological exploration, meteorology and climatology, seismological ventures, ionospheric research and glaciology. In the concluding section we describe U.S. American military and scientific activities in Greenland in terms of a three-fold colonial endeavour. First, the U.S. military attempted to gain power and control over Greenland territory. Second, it entered into negotiation and cooperation with the colonial power Denmark and constructed what John Krige has called a “consensual hegemony” over Danish terrain.¹⁰ Third, it mobilized American and Danish scientists and shaped Arctic geophysical and nuclear research.

Military and Scientific Challenges in the Arctic

The outstanding geopolitical and military role of the Arctic caused the U.S. military significant concern. The Strategic Air Command began flying B-29s along North America’s northern border. In the early 1950s, a big remote sensing system, the Distant Early Warning Line (DEW-line)

8. Cloud, 630; R.E. Doel, “The Earth Sciences and Geophysics,” in *Science in the Twentieth Century*, eds. J. Krige and D. Pestre (London: Harwood Academic Press, 1997), 391-416.

9. R.M. Friedman, “Playing with the Big Boys,” in *Into the Ice*, eds. E.-A. Drivenes and H.D. Jølle (Oslo: Gyldendal, 2006), 319.

10. Krige, *American Hegemony*, 5.

was built to detect incoming Soviet bombers approaching the U.S. mainland. It consisted of a chain of more than thirty ultra-high frequency (UHF) radar domes stretching three thousand miles along the northern perimeter of Alaska, Canada, and southern Greenland, four of them placed in Greenland, two on top of the icecap.¹¹

But the U.S. military had no or little experience with the challenge of maintaining aircrafts and radar stations in such a hostile environment. The Arctic largely represented a terra incognita which complicated the logistics of military missions enormously. Moreover, as Ronald E. Doel has pointed out, Pentagon officials and their civilian scientific advisors were well aware that the Soviets had a considerable lead in knowledge about the Arctic. Since the early twentieth century, Russian researchers engaged in numerous polar expeditions and even built drifting research stations on massive chunks of ice since 1937, while American scientists had largely ignored the polar regions.¹² Also in the post-war period, it was no secret that Soviet scientists actively pursued polar research. Tore Gjelsvik, the director of the Norwegian Polar Institute, estimated in 1982 that the Soviet Union had more than forty thousand people engaged in Arctic research and related activities in the Cold War since World War II.¹³

One 1949 directive of the Pentagon consequently called for new research into “snow, ice and permafrost; trafficability of soils and slopes; mapping and charting; weather analysis and climatology; and geophysical aspects of communications and navigation.” Other directives expanded the range of environmental factors to include the ocean underlying the ice cap, particularly “oceanography and hydrography of the Arctic Sea areas, including the Polar Basin, with special emphasis on sea ice, currents, and temperature-salinity structures,” as well as “associated cartography and charting.”¹⁴ Research efforts not only focused on the improvement of geophysical knowledge, but also covered the investigation of survival conditions in this hostile environment. In the preface to a study of survival experiences in the Arctic from 1953, an Air Force researcher stressed the extraordinary challenges. He emphasized that these regions “are not to be

11. J.L. Isemann, “To Detect, to Deter, to Defend: The Distant Early Warning (DEW) Line and Early Cold War Defense Policy, 1953-1957,” (PhD diss., Kansas State University, 2009); D.F. Winkler, *Searching the Skies: The Legacy of the United States Cold War Defence Radar Program* (Langley: United States Air Force Air Combat Command, 1997); T.W. Ray, *A History of the DEW Line, 1946-1964*, no. 31 (ADC Historical Study, 1965).

12. Doel, “What’s the Place,” 7; J. McCannon, *Red Arctic: Polar Exploration and the Myth of the North in the Soviet Union, 1932-1939* (New York: Oxford University Press, 1998).

13. S. Bones, “Norway and Past International Polar Years—A Historical Account,” *Polar Research* 26, 2 (2007): 202.

14. Doel, “What’s the Place,” 8.

entered casually or in an unprepared state. The environment presents unique problems not met elsewhere in the world. Constant study and experimentation are needed to adapt machines, materiel, and men to its demands.”¹⁵

Military demands fitted well with concurrent visions of polar researchers, who were interested in intensifying polar research and pushed for further scientific exploration of the Arctic. A number of individual scientific explorations run by various countries and internationally the coordinated campaigns of the first and second International Polar Years (IPY) in 1882-83 and 1932-33 had enhanced the knowledge about the polar areas, particularly in fields like meteorology, earth magnetism, studies of the aurora and ionospheric physics.¹⁶ At the same time polar research raised many more problems and questions. After World War II, geophysicists recognized the significant potential of new technologies developed during the war, such as rockets, radar, and computers, to advance basic geophysical research in the Arctic. The post World War II proliferation of aircraft in the Arctic marked a turning point in Arctic geological exploration. Conventional means of travel—ship, boat, canoe, or dog sledge—continued to be used for many years, but the ready availability of advanced air support offered new opportunities and a new style and pace of Arctic field work. In 1950, James van Allen, Sidney Chapman and Lloyd Berkner, who had been deeply involved in research for military applications during the war, developed the idea of a third IPY, which was quickly endorsed by major scientific institutions like the International Council of Scientific Unions. Between 1953 and 1958 the U.S. Congress appropriated a total of \$43.5 million for a global International Geophysical Year, 1957-58.¹⁷

Geoscientists and polar researchers shared scientific views like those presented by Moses Chiam Shelesnyak, the program manager of the Arctic Program at the U.S. Navy’s Office of Naval Research. In a paper given at the Arctic Institute of North America (AINA), Shelesnyak stated that the Arctic “nurtured scientific research in three respects: it was a

15. M. Farish, “Frontier Engineering: From the Globe to the Body in the Cold War Arctic,” *The Canadian Geographer* 50, 2 (2006): 181.

16. C. Lüdecke, “German Marine Weather Stations of World War II at Spitsbergen,” paper presented at the ICOMOS 13th General Assembly and International Symposium, Madrid, Spain, December 1-5, 2002, accessed January 25, 2011, <http://www.international.icomos.org/madrid2002/actas/39.pdf>; A. Elzinga, “Some Aspects in the History of Ice Core Drilling and Science from IGY to EPICA,” paper presented at the 3rd SCAR Antarctic History Action Group Workshop, Byrd Polar Research Center, Ohio State University, Columbus, OH, October 22-24, 2007.

17. S. Behr et al., “IPY History Reflects Progress in Science and Society,” *Witness the Arctic* 12, 2 (2007): 3; A.A. Needell, *Science, Cold War, and the American State: Lloyd V. Berkner and the Balance of Professional Ideals*, Studies in the History of Science, Technology, and Medicine (London: Harwood Academic Press, 2000).

frontier lacking a ‘systematic body of scientific data’, a simple, homogeneous and contained space ideal for experimental design and a region of profound intellectual interdependency that did not allow for closed, disciplinary forms of knowledge to survive.”¹⁸ But many scientists preferred to underrate the military context of this research—as represented by Shelesnyak. “[I]n general the fundamental aims of Arctic exploration are purely scientific,” A. Lincoln Washburn, geologist and director of AINA explained in 1957. They have the scope “to learn more about the North, to solve the many problems that confront us there and which must be solved before we are in a position to describe the North accurately and completely. From this point of view the North differs from no other region; where it does differ is in the fact that we know so little about it compared with most other parts of the world.”¹⁹ At the time, many commentators also saw the IGY as an exception to Cold War hostilities. Scientists believed that the IGY transcended geopolitical borders and that cooperation between East and West was indeed possible. Hugh Odishaw, the man chiefly responsible for organizing the vast American effort, described the IGY as “the single most significant peaceful activity of mankind since the Renaissance and the Copernican Revolution.”²⁰

In spite of contrary contentions, most senior scientists knew very well that the IGY—as other geophysical research efforts—was intimately connected with the national security aims of the leading nations involved. The IGY was a scientific success and contributed greatly to all core fields in the geophysical sciences, notably in the Arctic region. But research agendas and data collection, preservation, and use were closely interlinked with strategic Cold War politics.²¹ While military interests in the earth sciences provided an enormous opportunity to the geophysical sciences, it caused at the same time tensions, jeopardizing the autonomy and open, public nature of science. The IGY organizers realized the importance of selling science and international collaboration to the general public. The U.S. National Academy of Sciences, which played a major role in preparing for the IGY, began a public relations effort by the mid-1950’s that included the production of classroom material and a films series, called *Planet Earth*, designed for the general public. One of the explicit

18. Farish, “Frontier Engineering,” 179.

19. *Ibid.*, 180.

20. W. Sullivan, *Assault on the Unknown* ([London]: Hodder and Stoughton, 1962), 4.

21. Doel, “Constituting,” 636; Dennis, “Secrecy and Science,” 173; A. Elzinga, “Antarctica: The Construction of a Continent by and for Science,” in *Denationalizing Science: The Contexts of International Scientific Practice*, eds. E. Crawford, T. Shinn, and S. Sörlin (Dordrecht: Kluwer, 1992), 73-106; Needell, *Science*, 1-9; F.L. Korsmo, “The Genesis of the International Geophysical Year,” *Physics Today* 60, 7 (2007): 38-43.

goals of this campaign was to attract more students into the sciences. The campaign, however, was also used to manage the tensions between, on the one hand, the public nature of IGY as pure science and international collaboration and, on the other, the need for military confidentiality and secrecy.²²

Scientific Activities in Cold War Greenland

One of the biggest landmasses in the Arctic Sea, which drew the attention of military planners and experienced an enormous expansion of military activities and polar research in the post-war period, is Greenland. Greenland is characterized by extreme Arctic conditions and an ice cap which currently covers about 80 percent of its landmass. In spite of the harsh conditions, Greenland was settled intermittently since about 2500 BCE. Vikings from Scandinavia settled in Greenland since the late tenth century, but disappeared after about 450 years partly due to climatic deterioration. Denmark and Norway maintained land claims in Greenland since the thirteenth century. In 1536, they merged into a unified kingdom, which took up the Norwegian land claims on Greenland. When Norway was ceded to Sweden in 1814 after the Napoleonic Wars, the colonies, including Greenland, remained in Danish possession. After World War I, an open conflict with regard to the sovereignty of Greenland emerged between Denmark and Norway. Norway upheld territorial claims, while Denmark demanded full sovereignty over the whole of Greenland. When the Norwegian government officially occupied Eastern Greenland in July 1931, Denmark immediately brought the case before the International Court of Justice in The Hague. On 5 April 1933, the case was decided in favour of Denmark. Norway lost on all counts.²³

Norwegian territorial claims were strongly pushed by the nationalistic movement and by nationalistic polar researchers. One of them, the influential geologist Adolf Hoel (1879-1964), pressed for the Norwegian occupation of a part of Greenland and organized scientific expeditions to Greenland to further his case. He summarized simple principles of polar imperialism he demanded be pursued: “1. The first thing to do is to send out research expeditions, and thereby acquire (among other things) the requisite knowledge of the country’s natural environment and economic potential. 2. Then, establish scientific and social institutions, such as meteorological stations, seismographic stations, churches etc. 3. Then, encourage and

22. F.L. Korsmo, “Shaping Up Planet Earth: The International Geophysical Year (1957-1958) and Communicating Science through Print and Film Media,” *Science Communication* 26, 2 (2004): 162-87.

23. Drivenes and Jølle, 302-07.

support business and economic activity. 4. Create propaganda domestically and internationally to promote one's objectives. Make much of the work and results already achieved."²⁴ These principles, written around 1930, read like a blueprint for the planners of military activities in Greenland in the years to come, even though the emerging new colonialism would be a means rather than a goal in itself in Cold War politics.²⁵

The territory of Greenland was of great strategic interest to the USA in World War II and in the Cold War period. Greenland and Cold War politics were at the same time of pivotal significance for the political relationship between Denmark and the USA.²⁶ Single explorations or punctual observation points—as suggested by Hoel—did not any more suffice to serve the military interests and demands. During the war, after the German occupation of Denmark in 1940, the USA invoked the Monroe Doctrine for Greenland and established military bases and meteorological stations.²⁷ Also Germany made several efforts to establish meteorological stations on the eastern coast of Greenland, which were of prime importance for the German U-boat campaign.²⁸ These efforts were rebuffed by U.S. military. Immediately after the war, the Danish government tried to regain full sovereignty over Greenland, but with the Cold War beginning the USA was in no rush to leave the bases and other strongholds it had established during the war. The formation of NATO in 1949 turned USA and Denmark into closely allied nations leading the way to the defence agreement about Greenland of 1951.²⁹ This agreement opened the door for a large increase in American military and scientific activities in Greenland. The development of the new polar strategy around 1950 called for a massive build up of U.S. military capacity in the Arctic region, which demanded new knowledge on many levels and help from many different disciplines.

Important strongholds of American presence and military and scientific activity in Greenland were Thule Air Base on the west coast in the far north of Greenland and Camp Century, 138 miles east of Thule. In 1943, a Danish-American weather-station had been established in Thule (Pituffik), with an airstrip added in 1946. In 1951, the U.S. Air Force began construction of what would eventually become one of the most important

24. Drivenes and Jølle, 298.

25. N. Loukacheva, *The Arctic Promise: Legal and Political Autonomy of Greenland and Nunavut* (Toronto: University of Toronto Press, 2007), 130-34.

26. Dansk Udenrigspolitisk Institut (DUPI), *Grønland under den kolde krig: Dansk og amerikansk sikkerhedspolitik 1945-68* (Copenhagen: DUPI, 1997).

27. W.F. Kimball, *The Juggler: Franklin Roosevelt as Wartime Statesman* (Princeton: Princeton University Press, 1991), 112-14.

28. Lüdecke, "German," 39.

29. P. Villaume, *Allieret med forbehold: Danmark, NATO og den kolde krig. Et studie i dansk sikkerhedspolitik 1949-1961* (Copenhagen: Eirene, 1995).

foreign bases on Greenland, the Thule Air Base (TAB). Placed on in the north-western corner of Greenland, on the shortest route towards Soviet industrial centres, TAB was an anchor point for the refuelling of B-36 and later B-47 strategic bomber aircraft stationed at bases on the North American mainland. Thule became an important military hub and a key station for military intelligence and reconnaissance. When the DEW line was made partially obsolete by the advent of the Soviet ICBMs (Intercontinental Ballistic Missiles), the U.S. immediately started to develop the Ballistic Missile Early Warning System (BMEWS), which consisted of three UHF radar complexes placed in Thule, Clair (Alaska), and Fylingdale Moor (England). The Thule BMEWS, dominated by four gigantic fence antennas (measuring 120 metres by 50 metres), went into operation in 1960. As an ideal location for the servicing of polar orbiting satellites, TAB was also furnished with a Satellite Control Facility for tracking, command and telemetry in the early 1960s.³⁰ It is safe to say that TAB constituted a central part of the eyes and ears of the U.S. during the Cold War.

At the same time, TAB served as the basis for scientific investigation and exploration. Responding to the demand for new knowledge about the Arctic environment and operation in these regions the U.S. military called in a large number of specialists from fields such as atmospheric research, glaciology, geology, and engineering. Thule Airbase was the centre of these activities. It became the starting point of glaciological and geological exploration and hosted meteorological and ionospheric research facilities.

Based on experiences with two smaller camps, Camp Tuto and Camp Fistlench, the U.S. Army Corps of Engineers constructed Camp Century (“the city under the ice”) from 1959 to 1961. Camp Century consisted of twenty-eight electrically heated buildings that were hidden and protected in tunnels dug more than ten meters into the icecap. Between one and two hundred scientists and army personnel worked at this isolated spot all year round through most of its lifetime, 1960-1966. Camp Century was referred to by the U.S. Army as a scientific camp inside the Greenland icecap, and researchers carried out a large number of pure science as well as applied science experiments. They extracted, for example, ice cores from the top to several hundred metres under the surface of the icecap with the aim to study temperature variations in the last few centuries. They investigated problems like the plasticity of the ice and its variation as a function of depth and temperature, best practices for constructing camps under the ice (such as Camp Century), the reliability of railway systems installed in subsurface tunnels in the icecap and the use of a portable nuclear reactor to provide power and heat for the camp.³¹

30. C. Archer, “The United States Defence Areas in Greenland,” *Cooperation and Conflict* 23, 2 (1988): 123-44; J. Taagholt, “Thule Air Base,” *Tidsskriftet Grønland* 50, 2 (2002): 42-112.

31. C.M. Daugherty, *City under the Ice—The Story of Camp Century* (New York: Macmillan, 1963); E.F. Clark, *Camp Century: Evolution of Concept and History of Design, Construction and Performance*, Technical Report No. 174 (Hanover: U.S. Army Research and Engineering Laboratory, 1965).

Nuclear Science and Technology

For a large number of countries, scholarly studies cover the history of nuclear energy research and development. This also holds for Denmark proper.³² But nuclear R&D taking place in Greenland during the Cold War has not been subject to the same close scrutiny by historians. Exceptions are spectacular events such as Operation Crested Ice, a major cleaning-up effort launched after the Thule accident on 21 January 1968, when a U.S. Air Force B-52 bomber carrying four hydrogen bombs crashed into the frozen North Star Bay, approximately ten miles from Thule Air Base.³³

Greenland was not only a territory across which nuclear missiles would be directed and aircraft with nuclear bombs regularly manoeuvred. The U.S. Air Force, for example, deployed nuclear weapons at Thule Air Base at least from 1959 to 1965.³⁴ In a similar spirit, the U.S. Army during the late 1950s developed a secret project, named Project Iceworm, with the aim to deploy several hundred IRBM's (Intermediate-Range Ballistic Missiles) carrying nuclear warheads in a widespread system of tunnels under the surface of the Greenland icecap.³⁵ E. D. Weiss and N. Petersen argue convincingly that Project Iceworm represented an attempt of the U.S. Army to respond to the challenge of the ever growing nuclear threat from the USSR as well as to the challenge from the U.S. Air Force's Minuteman and the U.S. Navy's Polaris projects. Due to various political and technical problems, the huge Iceworm-project was never realized in practice. There are good reasons to believe that Camp Century was intimately connected to Project Iceworm. A deeper understanding of how Camp Century came into being, what came out of the multitude of experiments at the camp, and how intimately Camp Century was linked to Project Iceworm does not exist at present.

A related but more specific project was concerned with the PM-2A nuclear reactor. Installed during the autumn of 1960 in one of the roofed trenches of Camp Century, the PM-2A reactor delivered power as well as heat to the camp most of the time from November 1960 until 1964, when

32. H. Kragh et al., *Science in Denmark: A Thousand-Year History* (Århus: Aarhus University Press, 2008); H. Nielsen and H. Knudsen, "The Troublesome Life of Peaceful Atoms in Denmark," *History and Technology* 26, 2 (2010).

33. DUPI, *Grønland*, 451-484; P. Brink, *Thule-sagen. Løgnens univers* (Copenhagen: Aschehoug, 1997); D. Stiles, "A Fusion Bomb over Andalusia: US Information Policy and the 1966 Palomares Incident," *Journal of Cold War Studies* 8, 1 (2006): 49-67; J.C. Oskins and M.H. Maggelet, *Broken Arrow: The Declassified History of Nuclear Weapons Accidents* (Raleigh: Lulu.com, 2008).

34. DUPI, *Grønland*, 331.

35. Ibid., 357-60; E.D. Weiss, "Cold War under the Ice: The Army's Bid for a Long-Range Nuclear Role, 1959-1953," *Journal of Cold War Studies* 3, 3 (2001): 31-58; N. Petersen, "The Iceman that Never Came: 'Project Iceworm', the Search for a NATO Deterrent, and Denmark, 1960-1962," *Scandinavian Journal of History* 33, 1 (2008): 75-98.

it was removed and returned to the USA.³⁶ As the only power-producing reactor on Danish territory, the installation, functioning, and decommissioning phases of the reactor were followed closely by American experts as well as experts from the Danish nuclear power research facility at Risø. Details concerning the interaction between these two expert groups are not known, however, and many questions remain open. Did American and Danish nuclear experts agree on how to respond to technical or environmental problems with the reactor? Were there, for example, any serious discussions at Camp Century (or at Thule Air Base) concerning the safety of the reactor or the radioactive waste problem? Likewise, it is not known to what extent information on the reactor at Camp Century was available to Danes and Greenlanders.

A third nuclear R&D project in Greenland was Denmark's long-winded search for uranium and its efforts to extract this valuable element from solid rock deposits in Greenland. The first expedition with uranium prospecting in mind was launched immediately after the establishment of the Danish Atomic Energy Commission (AEK) in 1955. It was run as a collaborative project between AEK and the Danish Army, with Danish geologists from the Greenland Geological Survey (GGU) on the sideline, much to their dismay. Eventually, GGU became involved and the Army pulled out of the project. Much later, during the oil crisis in the 1970s with its accompanying increased interest in nuclear power, the Danish government financed the transfer of several hundred tons of uranium ore to Risø with a view to explore the economic viability of a commercial production of uranium for reactor fuel elements.³⁷ According to the current state of knowledge, it is unlikely that Danish uranium exploration and extraction activities were initiated first and foremost in response to U.S. pressures. Likewise, claims that the Danish Army became involved in uranium prospecting expeditions to Greenland because it wanted to develop its own nuclear weapons have not been substantiated. Further research will have to throw more light on these issues. Another long standing mystery also deserves attention: Why was GGU so reluctant to enter the uranium exploration project in Greenland in spite of heavy pressure from AEK and the Danish government?

Geological Exploration

During this period, Greenland geology was generally explored in three largely independent institutional contexts, each covering their region of the island. While the dawn of modern geological reconnaissance in Greenland

36. DUPI, *Grønland*, 360; Taagholt, "Thule Air Base," 72.

37. Henry Nielsen et al., *Til samfundets tarv: Forskningscenter Risøs historie* (Roskilde: Forskningscenter Risø, 1998), 336-59.

based on aircraft, helicopters, and new means of communication was marked by strong American geopolitical and military interests, it was also marred by considerable rivalry within the Danish geo-scientific community.

In northern Greenland, investigations were conducted under the auspices of the U.S. military. The extensive establishment of U.S. military installations in the High Arctic, during the Cold War required detailed knowledge of the terrain in order to establish quick and easy access to any locality in Greenland. For almost a decade during the 1950s the so-called Camp Tuto (short for ‘Thule take off’)—served as a kind of summer university at the edge of the Inland Ice. Helicopter-supported parties of scientists and military personnel, working from here or from icebreakers entered the scene in the late 1940s and 1950s. In this period the U.S. Geological Survey investigated and mapped the topography and geology of large areas of northern Greenland as part of U.S. military projects such as Operation Ice Cap (1953-54), Operation Defrost (1956) and Operation Groundhog (1957-60). To a large extent, the results of these investigations were initially confidential and therefore relatively unknown.³⁸

Although Danish geologists participated in some of these military operations, Danish efforts were mainly concentrated on the Eastern and Western parts of the island. Remarkably however, these investigations were carried out in two different and largely independent contexts. In the decades between World Wars I and II, the Danish geologist Lauge Koch led a number of highly successful topographical and geological surveys of North and East Greenland, notably the massive and technologically advanced Three Year Expedition to East Greenland 1931-1934, sent out by the Danish state in direct response to Norwegian sovereignty claims in the region. In the summer of 1933, The Three-Year Expedition celebrated the Danish victory at the international court in The Hague, with a total summer crew of no less than 109 participants. Initiating the use of systematic air survey and photography for topographic and geological mapping, this expedition was highly international in crew, employing geologists from Sweden, Switzerland, and Germany to England, France, and the USA. The fact that so many countries reaped benefits from the Danish efforts no doubt helped sway international opinion in favour of Denmark in the debacle with Norway over East Greenland. The successful

38. P. Dawes and A. Weidick, “W.E. Davies, hans arbejde i Nordgrønland og hans systematiske kortlægning af de istidsgeologiske aflejringer,” *Tidsskriftet Grønland* 47, 7-8 (1999): 270-282; P. Dawes and R.L. Christie, “History of Exploration and Geology in the Nares Strait Region,” *Meddelelser om Grønland. Geoscience* 8 (1982): 19-36; P. Dawes and R.L. Christie, “Geographic and Geological Exploration,” in *Geology of the Innuitian Orogen and Arctic Platform of Canada and Greenland*, ed. H. Trettin (Ottawa: Geological Survey of Canada, 1991).

Three Year Expedition was followed by another Two Year Expedition to the same region, with the same flavour of modern technology and international scientific cooperation under Koch's leadership.

But Koch's international success was matched by controversy at home. His focus on international scientific expertise had caused him to neglect his Danish colleagues at Copenhagen University, denying them any role in his expeditions, effectively blocking them from engaging in geological work in Greenland. In 1935, the tensions that had been escalating for almost a decade erupted in a fierce court debacle between Koch and his Danish colleagues, who accused Koch of improper scientific conduct. The Lauge Koch Case, as it came to be known, was settled with an unclear verdict at Supreme Court in 1938, and completely ruined any further possibility of collaboration between the parties. The situation was not helped, when the breakout of World War II put an end to all Greenland exploration, allowing the bitterness to develop further under the frustration of inactivity.³⁹

After World War II, Danish geological exploration of Greenland had to be re-established in a vastly different political context—nationally as well as internationally. In 1946, the Danish Greenland Geological Survey (GGU) was founded at the initiative of Koch's opponents in the Danish Geological Community, specifically designed to start operations in West Greenland, without interference from Koch.⁴⁰ While GGU established new connections especially with Norwegian and American geologists, Koch managed to re-ignite his international contacts to continue his East Greenland investigations as an independent consultant of the Danish Greenland Administration relying more than ever before on international expertise. For more than a decade after World War II two independent Danish state-subsidized geological surveys operated in Greenland with little or no cooperation—GGU to the West and Koch to the East⁴¹—until 1958 when Koch's funding was cut off in mid-expedition, putting an end to his career as an expedition leader. The reasons for the abrupt termina-

39. C.J. Ries, *Retten, magten og æren. Lauge Koch Sagen. En strid om Grønlands geologiske Udforskning* (Copenhagen: Lindhardt & Ringhof, 2003); C.J. Ries, "Maps, Armchairs, Dogsleds, Ships and Airplanes: Field Access, Scientific Credibility and Geological Mapping in Northern and North-Eastern Greenland 1900-1939," in *Scholars and Scientists in the Field: Studies in the History of Fieldwork and Expeditions*, eds. K.H. Nielsen, M. Harbsmeier, and C.J. Ries (Århus: Aarhus University Press, forthcoming 2011); C.J. Ries, "Inventing 'the Four-Legged Fish': The Palaeontology, Politics and Popular Interest of the Devonian Tetrapod Ichthyostega, 1931-1955," *Ideas in History* 2, 1 (2007): 37-78.

40. K. Ellitsgaard-Rasmussen, *En stjerne fødes-beretning om GGU's tilblivelse*, vol. 102, GEUS Report (Copenhagen: Miljø- og Energiministeriet, 1996).

41. N. Henriksen, "Geologisk kortlægning i Grønland—forudsætninger, metoder og resultater," *Geologisk Tidsskrift* no. 1 (2002): 1-48.

tion of Koch's activities are still uncertain, but have been interpreted as a sign of a government commitment to making GGU the only Danish state organization involved in the geological investigation of Greenland.⁴² The state of knowledge on post-war geological exploration in Greenland is limited and provides only little information on the causes for the tripartition into one American and two Danish endeavours and on the military and political agendas behind the Danish research efforts.

Meteorology and Climatology

The big landmass of Greenland was of significant interest for the weather services as well as for climatologists. Situated between Europe and America, meteorological stations in Greenland represented a crucial link for the extension and completion of the meteorological networks. Weather data from Greenland were of prime importance for European weather forecasting services as well as for flying aircraft or military missiles. New insights into weather systems and the role of polar fronts called for intensified meteorological observation in polar regions to improve the ability of forecasting weather. The director of the British Meteorological Office, Sir George Simpson, bemoaned in 1929 "a great blank [of knowledge] from 20°, more or less around the north pole. [...] our knowledge of polar meteorology is such that little further advance can be made by spasmodic meteorological observations," he contended. Necessary were "observations taken simultaneously in all parts of the polar regions" and "observations at a few representative positions which will give unbroken records extending over many years."⁴³ Sidney Chapman, British mathematician and geophysicist, dreamed of "half a million [pounds] a year" to be spent "on establishing a girdle of Polar stations."⁴⁴

Such visions had to await the post-World War II period. In 1873, the Danish Meteorological Institute established the first meteorological stations. By 1939, sixteen stations were in operation, fourteen at the west coast and two at the east coast.⁴⁵ During World War II, the U.S. established seventeen bases in Greenland, six of which were Army, Air Force or Navy bases. The rest mainly served for weather observation and radio communication. At the height of the war more than five thousand

42. O.W. Christensen, "GEUS—en ny national Geologisk Undersøgelse," *Geologisk Nyt* no. 4 (1995): 8-9.

43. G.C. Simpson, "Meteorology in Polar Regions," *The Geographical Journal* 74, 3 (1929): 258.

44. C. Close et al., "Meteorology in Polar Regions: Discussion," *The Geographical Journal* 74, 3 (1929): 263.

45. H. Petersen, "The Danish Meteorological Service in Greenland," *Arctic* 1, 1 (1948): 27-33.

men were stationed in Greenland.⁴⁶ One of the military stations was Thule in North Greenland. After the war, Denmark took over the meteorological stations established by the USA, but the U.S. military continued to expand its own line of meteorological research at Thule Air Base, covering for instance studies on reduced visibility (white out) and snow storms.⁴⁷ Until 1954, a meteorology inspector under the Danish Ministry of Greenland was responsible for running the stations. In December 1954 the Danish Meteorological Institute (DMI) took over responsibility.⁴⁸ Lively Danish-American cooperation continued throughout the Cold War period as can be seen from the fact that the DMI, according to one source, received a total of twenty-three research contracts and grants from U.S. military sources in the period from 1955 to 1977.⁴⁹

A related issue caused Pentagon officials considerable concern. Already in 1947 the impact of climate change was discussed in internal Pentagon meetings. The influential Swedish meteorologist Carl-Gustav Rossby called attention to the strategic implications of polar melting. Greenland is very sensitive to climatologic processes and experienced a strong warming period between about 1920 and 1945, much stronger than in other regions.⁵⁰ When the Pentagon queried military leaders as to what worried them most about Arctic unknowns, climate variation ranked sixth on a list of several dozen topics, underscoring their strong interest. Arctic climate variation threatened U.S. national security interests. Military structures built on ice or tunnels driven into the ice sheet might be threatened by destruction, roads and airports could in summers become impassable, in the worst case whole bases might turn out to be uninhabitable. Rossby found it relatively easy to convince Pentagon officials of the value of studying polar climate variation.⁵¹

The interest in a dense network of meteorological observations increased after the development of computer-based numerical weather simulation, another offspring of military war technology. Since the late 1950s, new hemispheric numerical weather and climate models were run in meteorological offices (for weather forecasting) and research institutions (for investigating the climate system and climate change). Data from Greenland

46. DUPI, *Grønland*, 64.

47. Taagholt, "Thule Air Base," 53.

48. DMI, *Meteorologisk Institut gennem hundrede år 1872-1972* (Copenhagen: Danmarks Meteorologiske Institut, 1972).

49. O. Wilkes and J. Øberg, *Military Research and Development in Denmark and Greenland* (Lund: Department of Peace and Conflict Research, Lund University, 1982).

50. R. Scherhag, "Eine bemerkenswerte Klimaänderung über Nordeuropa," *Annalen der Hydrographischen Meteorologie* 64 (1936): 96-100; Hans Ahlmann, "Klimaschwankungen der letzten Jahre," *Naturwissenschaftliche Rundschau* 4 (1951): 160-63.

51. Doel, "What's the Place," 6.

proved essential for running such models, and Greenland hence occupied a strategic geographic location.⁵² In 1963 the World Weather Watch and in 1967 the Global Atmospheric Research Program (GARP) were established as coordinated efforts to create denser networks for the collection of meteorological and climatologic data. In 1978-1980 the \$ 500 million Global Weather Experiment took place in the framework of GARP.⁵³ U.S. and Danish research activities in Greenland were integrated in these efforts. While U.S. scientists pioneered weather and climate simulation from the very beginning, the Danish Meteorological Institute specialized in the development and application of regional weather and climate modeling since the early 1980s.⁵⁴

Many scholars have emphasized the strong link between military interest and meteorology in the nineteenth and twentieth centuries.⁵⁵ The Cold War period certainly strengthened these links. In the second half of the twentieth century, atmospheric pollution and environmental interests became new influential drivers of meteorological and related research efforts.⁵⁶ It is an open question how the rise of environmentalism and the increased interest in phenomena like air pollution and climate change related to military interests, and what impacts they had on military research efforts.

Danish-American Seismological Ventures

In the late 1950s both superpowers came under severe public pressure to give up further nuclear bomb tests in the atmosphere and later underground tests as well.⁵⁷ Atmospheric tests were easily spotted, but nuclear scientists, diplomats, and policy-makers soon recognized that

52. K.C. Harper, *Weather by the Numbers: The Genesis of Modern Meteorology, Transformations* (Cambridge, MA: MIT Press, 2008), 234.

53. R.J. Fleming, T.M. Kaneshige, and W.E. McGovern, "The Global Weather Experiment, 1. The Observational Phase through the First Special Observing Period," *Bulletin of the American Meteorological Society* 60, 6 (1979): 649-61.

54. A.M. Jørgensen and T.S. Jørgensen, "Meteorologi og atmosfærefysik," in *Polarforskning. Status 1992* (Copenhagen: Kommissionen for Videnskabelige Undersøgelser i Grønland, 1992), 81-88.

55. J.R. Fleming, *Meteorology in America, 1800-1870* (Baltimore: John Hopkins University Press, 1990); K.C. Harper, "Meteorology's Struggle for Professional Recognition in the USA (1900-1950)," *Annals of Science* 63, 2 (2006): 179-99; Harper, *Weather*; Robert Marc Friedman, *Appropriating the Weather: Vilhelm Bjerknes and the Construction of a Modern Meteorology* (Ithaca: Cornell University Press, 1989).

56. C.A. Miller and P.N. Edwards, *Changing the Atmosphere: Expert Knowledge and Environmental Governance, Politics, Science, and the Environment* (Cambridge, MA: MIT Press, 2001).

57. R.A. Divine, *Blowing on the Wind: The Nuclear Test Ban Debate, 1954-1960* (New York: Oxford University Press, 1978); P.G. Schrag, *Listening for the Bomb: A Study in Nuclear Arms Control Verification Policy* (Boulder: Westview Press, 1989).

improved seismological knowledge was crucial for the detection of underground nuclear explosions. Consequently, the Eisenhower administration initiated a comprehensive R&D program in seismology, known as Project Vela Uniform, a project that increased the federal annual support for seismology by a factor of thirty.⁵⁸

A substantial part of this support was used to establish 120 seismic stations around the world, the so-called World Wide Net of Standardized Seismographs (WWNSS), which was already initiated during the International Geophysical Year 1957-58. Three of the WWNSS stations were placed in Greenland and one in Copenhagen, all four with the participation of the Danish Geodetic Institute. The institute also represented Denmark in the UN negotiations about seismological surveillance of underground nuclear tests. Despite the establishment of this network, the problem of detecting underground tests—i.e., distinguishing nuclear tests from earthquakes—proved difficult to resolve. From a seismological and strategic point of view, the stations in Greenland were very important. Since there is little natural seismic activity in Greenland, the detection of “unnatural” disturbances would be easier in Greenland than in most other places. Danish scientists greatly profited from and contributed to the Project Vela Uniform. An example is the influential Danish seismologist Inge Lehmann. Retired from her post as head of the seismological section at the Geodetic Institute in 1953, Lehmann moved for extended periods to the USA and participated in the Project Vela Uniform.⁵⁹ Little is known, however, about this cooperation and its links to military interests in Greenland.

Ionospheric Research

A research field ranking high on the agenda of geophysicists already prior to World War II and one of the focus areas of the second IPY was ionospheric research. After World War II, ionospheric research expanded enormously. In terms of manpower and economic resources this seemingly esoteric field became one of the largest scientific endeavours in Greenland. The ionosphere is of vital importance for radio communication because of its ability to reflect radio waves. In the Arctic region and especially inside the auroral zone the ionospheric conditions turned out to be particularly complex. Periods with high absorption of radio waves (blackouts) occurred frequently. In periods with maximum northern light activity total blackouts

58. K.H. Barth, “The Politics of Seismology: Nuclear Testing, Arms Control, and the Transformation of a Discipline,” *Social Studies of Science* 33, 5 (2003): 743-81.

59. T.J. Levin and R.E. Doel, “The Lamont-Doherty Earth Observatory Oral History Project: A Preliminary Report,” *Earth Sciences History* 19, 1 (2000): 26-32.

of high frequency radio communication could last up to one week. Obviously, reliable radio communications was of primary importance to commercial fishing and flight as well as to all sorts of military operation. Hence the strong interest in this field. By the mid-1960s more than one hundred ionospheric stations were being operated all around the world with nine or ten active research sites placed in Greenland.⁶⁰

New ionospheric research efforts in the 1950s were organized as a cooperative Danish-American effort from the very beginning. The first ionospheric station run by Danish scientists was erected in 1951 in Godhavn (now Nuuk). One year later, U.S. authorities built their first station in Narsarsuaq, which was eventually handed over to Denmark in 1957. These stations and further smaller research facilities measured ionospheric properties on a daily basis. The collected data were sent to the U.S. weather forecast centre in Boulder, Colorado, and the North Atlantic Radio Warning Services. A substantial amount of related ionospheric research was also conducted at newly enhanced research facilities at the Danish Technical University and the Danish Meteorological Institute in Copenhagen.⁶¹

In the late 1950s, the U.S. military became increasingly interested in very low frequency (VLF) communication. Key navigation and communication systems developed by the U.S. military during the early phase of the Cold War used the VLF band, in particular LORAN (Long Range Navigation) and OMEGA. Initially developed in the 1950s and the following decade to be used for navigating nuclear bombers across the North Pole to Russia, OMEGA was later found to be useful for submarine navigation. In the 1960s, the Survivable Low Frequency Communications System (SLFCS) was developed to provide a secure communications system in the event of a nuclear attack.⁶² Since the properties of the ionosphere within the auroral zone resemble those that occur during and after a nuclear war, the northern region facilitated unique possibilities for testing the reliability of electronic equipment in the case of a nuclear war. Furthermore, military interest in VLF ionospheric data was strong, because such data proved useful for the surveillance of atmospheric nuclear tests.⁶³

In 1957, Danish researchers started research in Arctic VLF radio noise phenomena. In 1964, a new VLF facility was erected at the Danish part of Thule Air Base. Two years later it merged with a similar neighbouring

60. E. Brun, "Greenland," *Arctic* 19, 1 (1966): 62-69.

61. H. Knudsen, "Dansk og amerikansk videnskab på Grønland," in *Den kolde krig og Danmark. Gads Leksikon*, eds. T. B. Olesen, and al. (Copenhagen: Gad, 2011).

62. Wilkes and Øberg, *Military Research and Development in Denmark and Greenland*; O. Wilkes and N.P. Gleditsch, *Loran-C and Omega: A Study of the Military Importance of Radio Navigation Aids* (Oxford: Oxford University Press, 1987).

63. J. Taagholt and H.C. Bach, "Hvad foregår der af videnskabelig aktivitet i Grønland i dag?," *Tidsskriftet Grønland* 23, 7 (1975): 213-20.

U.S. station handed over to the Danes. Ionospheric research activities were frequently presented as basic science, which is true in some instances, though application-oriented interests were clearly evident as well. The Danish efforts were to a large extent supported by U.S. institutions like the National Science Foundation, the National Bureau of Standards and various U.S. military bodies.⁶⁴ It is unclear, however, to what extent these Danish research efforts related to U.S. and NATO military R&D and to what extent military interests influenced the choice of research topics and research directions. In later decades, rapidly declining research funding may have forced ionospheric researchers to shift to new research topics and fields. This is a question that needs to be explored in depth, but judged by later articles published by some of the key figures in the Danish ionospheric business, many of them turned their attention to related environmental topics such as ozone layer physics and climate science in the 1980s.

Glaciological research

Glaciology was still in its infancy around the time of World War II, but the shift of military-strategic interests towards the Arctic as a potential battlefield in the Cold War led to an extensive build-up of research activities in this field. In 1949, the Snow, Ice and Permafrost Research Establishment (SIPRE) was founded under the U.S. Army Corps of Engineers to conduct basic and applied research in glaciology and permafrost science.⁶⁵ SIPRE's research activities in Greenland were primarily located around the Thule Air Base and at stations on the ice cap. Primary focus of these studies was the physics and dynamics of the ice: how to use ice as a building material, how to build roads and runways on land- and sea-ice, and how to construct and maintain military installations *on, in, and under* the ice. The studies were both large- and small-scale: from traverses across the whole ice cap for the mapping of snow accumulation and flow, to laboratory studies of crystal formation and plastic deformation of ice. Activities peaked in the early-1960s, with the establishment of Camp Century by the U.S. Army Corps of Engineers and its associated Cold Regions Research and Engineering Laboratory (CRREL), a successor organization of SIPRE. In the mid-1960s, the U.S. Army gave up plans to establish a wider network of tunnels under the ice to hide nuclear missiles, the so-called project Iceworm.⁶⁶ As a result,

64. J. Taagholt, "Danish Arctic Ionospheric Research," *Arctic* 25, 4 (1972): 251-262; Taagholt and Bach, "Hvad foregår der," 213; J. Taagholt, "Den videnskabelige aktivitet på Thule Air Base," *Tidsskriftet Grønland* 25, 9-10 (1977): 279-91; Taagholt, "Thule Air Base," 45-49.

65. E.A. Wright, *CRREL's First 25 years 1961-1986* (Hanover: CRREL, 1986).

66. Petersen, "The Iceman," 87-93.

CRREL's military glaciological research waned. Instead, growing environmental concerns motivated support for an international ice-drilling and -analysis project to reconstruct past climate.⁶⁷

Concurrent with U.S. activities, several European countries sent expeditions to Greenland. The French Expédition Polaires Françaises (EPF) lasted from 1948-53. Another French, German, Austrian, Swiss, and Danish collaborative Expédition Glaciologique Internationale au Groenland (EGIG) had crossed the ice sheet during the International Geophysical Year in order to take measurements of the accumulation and flow of ice, and to drill short ice cores for physical and chemical analysis.⁶⁸ Since the IGY, when ice core research entered the stage and became a focus of glaciological research, Denmark started to become a more active player in Greenland glaciology.⁶⁹ Ice cores allowed the collection of environmental information stored in the ice, such as nuclear fallout, volcanic dust, and—since the 1960's—the historical temperature record which could be reconstructed many thousand years back in time through isotope analysis of the annual snow layers. Such information was extracted from ice cores drilled by EGIG, SIPRE, and CRREL. In 1966, CRREL succeeded in the first penetration of the ice sheet to its entire depth at Camp Century in northern Greenland. Ice core analysis proved so valuable for paleoclimatological investigation, that it came to dominate glaciological research in the 1970s. An American-Danish-Swiss collaboration drilling through the ice sheet to gain knowledge on past climate changes proved to be one of the most important glaciological activities in this decade. It considerably improved the understanding of past temperature excursions and the rapidity with which major climatic variations can occur.

Only recently ice core research has become a subject of historical analysis.⁷⁰ A large number of questions about glaciological research in Greenland still need to be answered. Research institutions like SIPRE and CRREL were established in response to military needs and greatly profited from military funding. But it is an open question to what extent military interests shaped research projects at these institutions or to what extent scientists managed to seize the opportunity of military funding for furthering their own research interests. European glaciology in the early Cold War period was guided by national and geographical interests and spearheaded by France, which was present in both polar regions.

67. Maiken Lolck, *Klima, kold krig og iskerner* (Århus: Aarhus Universitetsforlag, 2006); E. Kolbert, "Ice Memory: Does a Glacier Hold the Secret of How Civilization Began—and How it May End?" *The New Yorker*, January 7, 2002, 30-37.

68. C.C. Langway, "The History of Early Polar Ice Cores," *Cold Regions Science and Technology* 52, 2 (2008): 101-17.

69. *Ibid.*, 108

70. Lolck, *Klima*; Elzinga, "Some Aspects..."

Switzerland also had a strong tradition in glaciology, while Denmark took part mainly as the host country. With our current state of knowledge, little can be said about the differences of American and European glaciological expeditions in Greenland in terms of means, methods, and aims, just as little is known about collaboration and competition of European and American glaciologists. How did Danish sovereignty in Greenland influence these collaborative efforts? Furthermore, glaciological expeditions in polar regions traditionally caught the public imagination. Further research will have to establish how the ice cap changed in the scientific as well as the public perception in the post-war period from a robust medium for engineering and military operations to a vulnerable element of the Earth system.

Science, Technology, and Colonial Endeavours

The U.S. military had strong interest in controlling and using Greenland territory as an important building block in its Cold War strategy. It started a new colonial endeavour with Danish consent and with little attention to the local Inuit population. Thule Air Base, for instance, was located half way between New York and Moscow. Its location allowed the Americans to monitor Soviet military activities and, most importantly, to give early warning of any possible first nuclear strike. The Thule district had been inhabited by native Inughuit (northern Inuit) for centuries, the main settlement being Ummannaq. In 1953, the U.S. Army decided to construct four large antiaircraft batteries to protect the base. One of these batteries was going to be situated near Dundas Mountain in the vicinity of Ummannaq. As a consequence, the Inughuit were forced to move immediately and given very few days notice to pack up their belongings and sledge about one hundred kilometres north to the new settlement Qaanaaq.⁷¹ This American colonialism had little to do with imperialist motivations and colonial rule and exploitation of a traditional kind. It rather served to establish outposts in Greenland settled by military, technological, and scientific experts to respond to the Cold War confrontation, restrain Soviet ambitions and power, and achieve consensual hegemony in the Western world.⁷²

Denmark, a small country in the twentieth century which exerted sovereignty over this large, but for most of its history marginal territory, was abruptly catapulted into world politics after World War II. The USA with its interest in Greenland pulled Denmark into a close alliance and

71. J. Brøsted and M. Fægteborg, *Thule—fangerfolk og militæranlæg* (Copenhagen: Akademisk Forlag, 1987); [s.a.], "Invasjonen af Thule og befolkningens fordrivelse," *Tidsskriftet Grønland* 43, 7-8 (1995): 310-20.

72. Krige, *American Hegemony*, 29.

amidst crucial Cold War politics. In many ways Denmark profited from this sudden interest and involvement. Its political status and influence increased and its military forces as well as its research institutions enjoyed significant flows of money from the U.S.. Historians disagree to what extent Denmark's new geopolitical position can be regarded a "Greenland card" and to what extent changing Danish governments have actively used this card to further its economic and political agendas.⁷³

Denmark maintained a strong political position regarding Greenland. For instance, the 1951 agreement restricted U.S. military activities to few very limited geographical areas. Furthermore, all U.S. research activities needed approval from Danish authorities. And the U.S. research activities were subject to extensive surveillance from the Danish authorities through the work of a scientific advisor to the Danish liaison officer of TAB. But while Denmark has profited from the strong American interest in Greenland and from intensive cooperation, it also had to accommodate to manifold pressures. Strong American research activities also gave rise to considerable competition between American and Danish scientists. The Danish government may have felt forced to show its flag by strongly and actively engaging in research projects which it otherwise would possibly not have pursued.

Denmark had experienced a similar situation, though on a much smaller scale, when Norway's nationalist-inspired exploration activities in Greenland escalated in the early 1930s. In response Denmark started an immense research effort that overshadowed Norway's activities.⁷⁴ It must have been obvious to Danish governments that massive U.S. activities in Greenland did not simply represent friendly-minded precautionary measures responding to mounting tension between the Eastern and the Western blocks. U.S. military and scientific presence in Greenland represented at the same time a new form of colonialism threatening Danish sovereignty and autonomy. Furthermore, Cold War tensions did not simply and only make Greenland a trump card, but also threatened Denmark's own security interests, given the fact that Greenland represented one of the most important strategic regions in the Cold War and could have become a principal location of a hot war. It is an open question, with which intentions and goals the various Danish actors (in government, military, and science) manoeuvred—and managed to manoeuvre—within this complex bundle of pressures and interests.

73. B. Lidegaard, *I kongens navn: Henrik Kauffmann i dansk diplomati 1919-1958* (Copenhagen: Samleren, 1996); DUPI, *Grønland*, 273-275; P. Villaume, "Henrik Kauffmann, den kolde krig og de falske toner," *Historisk Tidsskrift* 16, 2 (1997): 491-511; N. Petersen, *Europæisk og globalt engagement. Dansk udenrigspolitik historie*, vol. 6 (Copenhagen: Gyldendal, 2004).

74. Drivenes and Jølle, 299.

Sovereignty over Greenland was of vital geopolitical importance to Denmark, and scientific activities played a fundamental role in the Danish foreign policy strategy to regain and bolster its national claims for full sovereignty over Greenland. Furthermore, scientific activities and explorations helped to legitimize the continued colonial rule in Greenland in a post-war world of rapid decolonization. It is an open question, however, to what extent scientific and technological projects were aimed at furthering the development of the Greenlandic society and whether these aims have been reached. Science and technology certainly had become important vehicles for the construction of national security and foreign policy interests in U.S. politics. For Denmark, they had (not in the least in response to U.S. moves) assumed a similar role, albeit with partly different sets of goals.

John Krige and Kai-Henrik Barth have identified three major historical contexts demanding further attention in the investigation of post-war science and technology: the atomic age, the postcolonial world order, and (military) patronage of science and technology.⁷⁵ In the case of Greenland all these contexts obviously mattered. Issues of nuclear weapons and nuclear power were central to the reconfigurations of the international space through the Cold War. Here, the territory of Greenland featured prominently in military interests. Nuclear science and technology was developed in several directions, such as uranium exploration, the construction of a nuclear reactor under the ice, seismological research to keep track of underground nuclear tests, and the plans for the construction of a widespread system of tunnels in the Greenland icecap for the deployment of nuclear IRBMs.

Post-war science and technology in Greenland were also affected by the impacts of an emerging postcolonial world order. As a counterbalance to the sweeping decolonization processes in many regions of the world, major western democratic powers sought to maintain their nuclear monopoly and to limit proliferation of nuclear science and technology. Contrary to these decolonization developments, the USA and Denmark sought to intensify and exploit colonial control in Greenland. The invasion of armies of scientists, many of whom were soldiers at the same time, appeared a proper tool for securing territorial knowledge and control. Denmark, with its interest both in Greenland and in the development of its own nuclear capabilities, had to cope with these diverse pressures. Science and technology provided an obvious space for tightening

75. J. Krige and K.-H. Barth, "Introduction: Science, Technology, and International Affairs: New Perspectives," in *Global Power Knowledge: Science and Technology in International Affairs. Osiris*, eds. J. Krige and K.-H. Barth (Chicago: University of Chicago Press, 2006), 1-21.

international relations, pursuing nuclear interests, and perpetuating colonial goals. Greenland, thus, ranked high with regard to funding relevant scientific and technological research activities.⁷⁶

In many instances, military patronage refashioned scientific identities and scientific research activities in the post-war period.⁷⁷ In the case of Greenland, military patronage for scientific and technological research was of supreme importance in accelerating the quick expansion of the earth sciences and of geophysical expertise and knowledge. Most research activities, but also progress in institutionalization and discipline building, in the 1950s and 60s thrived through heavy military investments.⁷⁸ Whole scientific institutions were created or generously nurtured, new research fields and directions explored and consolidated, and a large number of scientists in these new fields educated and employed, which on their part helped to create new generations of researchers. But worlds so diverse as the realm of science and the military with their different perspectives, traditions, rules, and goals in no way engendered smooth, stable, and peaceful coalitions, but rather continuously fragile alliances subject to multiple tensions and in need of abiding moderation. While scholars agree that the geophysical sciences were strongly affected by Cold War politics and greatly expanded, there is no general agreement how the Cold War shaped scientific disciplines and how, in turn, these disciplines shaped the Cold War. Paul Forman and Stuart W. Leslie forcefully put forward the “distortionist” view, arguing that military interests defined the directions of research fields and disciplines to a considerable degree.⁷⁹ Others scholars, like Joan L. Bromberg, preferred a more cautious approach and objected to strong generalizing claims.⁸⁰ Ronald E. Doel has argued “that patronage for military-relevant fields in the earth sciences shaped the

76. DUPI, *Gronland*, 241-247.

77. P. Forman, “Behind Quantum Electronics: National Security as Basis for Physical Research in the United-States, 1940-1960,” *Historical Studies in the Physical and Biological Sciences* 18, 1 (1987): 149-229; S.W. Leslie, *The Cold War and American Science: The Military-Industrial-Academic Complex at MIT and Stanford* (New York: Columbia University Press, 1993); R.S. Lowen, “Exploiting a Wonderful Opportunity—The Patronage of Scientific Research at Stanford University, 1937-1965,” *Minerva* 30, 3 (1992): 391-421; R.S. Lowen, *Creating the Cold War University: The Transformation of Stanford* (Berkeley: University of California Press, 1997); D. Hounshell, “The Cold War, RAND, and the Generation of Knowledge, 1946-1962,” *Historical Studies in the Physical and Biological Sciences* 27, 2 (1997): 237-67; D. Kaiser, “The Postwar Suburbanization of American Physics,” *American Quarterly* 56, 4 (2004): 851-88.

78. Doel, “Constituting,” 635-636; Barth, “The Politics,” 743-744; J.D. Hamblin, *Oceanographers and the Cold War: Disciples of Marine Science* (Seattle and London: University of London Press, 2005); Krige, *American Hegemony*, 9-14.

79. Forman, “Behind”; Leslie, *The Cold War*.

80. J.L. Bromberg, “Device Physics vis-a-vis Fundamental Physics in Cold War America—The Case of Quantum Optics,” *Isis* 97, 2 (2006): 237-59.

questions that researchers asked and valued.”⁸¹ Military interests nurtured specific fields, notably in the geophysical sciences, while the biological sciences remained far behind and only later began to expand driven by rising environmental interests. Doel noted not only a rearrangement of the landscape of disciplines and the relative weight of individual scientific fields, but military patronage in the geophysical sciences also “limited their interactions with colleagues in the biological realms of environmental sciences research” and consequently reshaped barriers to and opportunities for interdisciplinary research activities.⁸²

Kai-Henrik Barth, in contrast, concluded for the case of seismology—which indeed profited enormously from military engagement—that scientists succeeded in maintaining their professional academic ethos more or less uncompromised.⁸³ Similarly, Maiken L. Lolck showed for the case of ice core research that scientists even managed quite well to use military and economic interests as a vehicle for some of their own concerns.⁸⁴ These examples suggest a great diversity and complexity of interactions depending on the individual research fields and research contexts. In the case of research in Greenland, the state of knowledge is far too insufficient to justify any conclusions. While the “distortion” argument has to be considered and investigated in further research, simple and generalized answers appear improbable.

Another type of “distortion” involves the role of scientists in the Cold War period. Military patronage not only affected research activities and results, but scientific investigation and scientists also affected military policy and—more generally—foreign affairs to a larger extent than ever before. Earth scientists became involved in the negotiation of major multinational agreements like the Antarctica Treaty of 1960 and the Limited Nuclear Test Ban Treaty of 1963. Doel noted an “assimilation of science into the highest levels of national security and foreign policy planning” and even concluded that the earth sciences became “elements of U.S. foreign policy.”⁸⁵

One of the important tensions involved in the military patronage of scientific research is that of confidentiality versus publicity. While most military operations are based on controlling flows of information, it is commonly agreed that science needs open publishing and unrestrained communication among peers across national borders to flourish.⁸⁶ Military

81. Doel, “Constituting,” 635.

82. Ibidem.

83. Barth, “The Politics,” 766.

84. Lolck, *Klima*, 139.

85. Doel, “Constituting,” 636.

86. R.E. Doel and A.A. Needell, “Science, Scientists, and the CIA: Balancing International Ideals, National Needs, and Professional Opportunities,” in *Eternal Vigilance? Fifty Years of the CIA*, eds. R. Jeffreys-Jones and C. Andrew (London: Frank Cass Publ., 1997), 59-81.

planners in the USA and in Denmark, and scientific institutions involved in Greenland research had to negotiate and define the boundary between what is made publicly available and what is kept secret. In the post-war period, military demands for classification clashed with strong claims of scientists and science administrators, who publically demanded open communication as a prerequisite of competitive science. In his report to the President, war science administrator Vannevar Bush fiercely demanded “to remove the rigid controls,” which had to be imposed during the war to “recover freedom of inquiry and that healthy competitive scientific spirit so necessary for the expansion of the frontiers of scientific knowledge.”⁸⁷

Various researchers have shown that no clear line between classified and unclassified science could be drawn. Van Keuren argued that “it was relatively easy for very basic, unclassified research to co-exist with very applied and deeply classified R&D projects. [...] The intermeshing fabric that resulted was not simply a matter of black and white, but rather of numerous shades of gray.”⁸⁸ The military could not keep scientists totally from communicating with their international peers. Westwick observed in scientific establishments engaged in classified research “a series of practical adjustments—the resumption of conferences, the creation of committees—that mitigated the effects of secrecy. [...] Even in the most highly classified weapons programmes, compartmentalization does not appear to have hampered the exchange of information.”⁸⁹ Even if “barriers between classified and unclassified research remained impermeable, recent scholarship on the National Laboratory system in the USA indicates that the ‘closed world’ retained many of the norms of ‘open’ science,” David Hounshell concluded.⁹⁰ The “classification of research within the national security state was not as simple as it might seem.” Policies such as the compartmentalization of information “did not work as intended by those who put them into place.”⁹¹

It is arguably an open question whether observations like these also apply to research efforts in Greenland. Classified research in Greenland had a different character than in many other U.S. establishments and locations. The military did not only fund established scientific institutions in Greenland, but had to maintain, establish, and administer its own new

87. V. Bush, *Science, The Endless Frontier: A Report to the President* (Washington: United States Government Printing Office, 1945), 12.

88. D.K. van Keuren, “Cold War Science in Black and White: US Intelligence Gathering and its Scientific Cover at the Naval Research Laboratory, 1948-62,” *Social Studies of Science* 31, 2 (2001): 223-24.

89. P.J. Westwick, “Secret Science: A Classified Community in the National Laboratories,” *Minerva* 38, 4 (2000): 386f.

90. Hounshell, “The Cold War,” 292f.

91. *Ibid.*, 293; see also Dennis, “Secrecy and Science,” 175.

research stations. Did the military thus manage to exert more efficient control and to implement stricter provisions for the classification of scientific results, as in the case of U.S. university research for the military, to take but one example? Or did the fact that polar researchers travelled back and forth from home institutions to Arctic stations and explorations rather counteract strict classification schemes? Which military institutions controlled the flow of information, which provisions were taken to discipline scientists, and how was control exerted? Currently, there is no answer to these questions. We don't know how military officials and scientists negotiated and managed the clash of culture between open and classified science, which aims and stakes were at play, and which communication and negotiation processes took place.

The International Geophysical Year of 1957-58 provides an example of the delicate balance struck between confidentiality and publicity both in the scientific arena (open accessibility of scientific data and results) and in relations between science and the public (dissemination of scientific results to wider public audiences). The IGY produced large sets of scientific data which were to be collected in newly established World Data Centers (WDCs). Scientists demanded and struggled for the free flow of the data, which had great value for further research. Cold War considerations however led both the U.S. and USSR to establish their own WDCs for each of the fourteen IGY disciplines; which then were named WDC-A and WDC-B, respectively.⁹² Under the auspices of the U.S. National Committee for the IGY, a special task force was established to initiate a public information and education campaign. However, the task force encountered many problems in meeting its target. For one thing, Cold War politics heightened the difficulty of selling an explicitly international science program such as the IGY to the general public. Many research projects remained classified, and scientists with international affiliations easily fell under suspicion of left-wing tendencies. Moreover, the task force experienced problems caused by multiple actors with unclear or overlapping roles, poorly articulated goals, ambitious expectations, with little money to back them, and a lack of clear management authority.⁹³

A second—but no less contentious—issue was the communication of military and scientific activities in Greenland to the broader public. The early Cold War period was characterized by an increased number of initiatives aimed at strategic science communication “to improve the attitude of members of the public toward science as a body of knowledge,

92. Behr et al., “IPY History,” 3.

93. Korsmo, “Shaping Up,” 182.

science as a way of knowing about the world, scientists as individuals, and the particular requests for support and funding that came from scientific institutions.”⁹⁴ Many different actors such as commercial publishers, scientific associations, science writers, military institutions, government agencies, and many more took an interest in science communication as a deliberate means of serving specific interests. But the public image of science as an open and democratic venture did not fit well with the military’s need for confidentiality. Demands for open science as in Vannevar Bush’s report “represented an inaccurate, idealistic view of science” and “proposed an impractical, improbable array of promises.”⁹⁵

Military planners did not see much need to spread information about their Arctic ventures. Nevertheless, in the case of Greenland they had to deal with Denmark (which officially had to be involved) and—not least—with the local population, indigenous Inuit as well as Danes (if they cared much at all). One strategy of the U.S. military was apparently to spread information about the scientific aspects of the engagement, which seemed a less compromising way of justifying a massive presence in Greenland. Endeavours of Arctic exploration became a common genre for popular accounts.⁹⁶ Articles on scientific matters appeared frequently in press material such as the “Thule Times.” Furthermore, recent findings in the Danish National Archives show that dozens of journalists and writers from many western countries visited Camp Century in 1960-61 and later wrote books and articles about this extraordinary place. In the USA, the U.S. Information Agency (U.S.I.A.), tasked with communicating positive achievements to the rest of the world through much of the Cold War, prepared a photographic essay on Camp Century in the early 1960s.⁹⁷

94. B. Lewenstein, “The Meaning of ‘Public Understanding of Science’ in the United States after World War II,” *Public Understanding of Science* 1, 1 (1992): 46; see also K. Moore, *Disrupting Science: Social Movements, American Scientists, and the Politics of the Military, 1945-1975*, Princeton Studies in Cultural Sociology (Princeton: Princeton University Press, 2008); J.L. Rudolph, *Scientists in the Classroom: The Cold War Reconstruction of American Science Education* (New York: Palgrave, 2002); J. Wang, “Scientists and the Problem of the Public in Cold War America, 1945-1960,” *Osiris* 17 (2002): 323-47.

95. M.C. LaFollette, *Making Science Our Own: Public Images of Science 1910-1955* (Chicago: University of Chicago Press, 1990), 15-16.

96. J. Mirsky, *To the Arctic! The Story of Northern Exploration from Earliest Times to the Present* (New York: A.A. Knopf, 1948); E. Mountevans, *Arctic Solitudes* (London: Lutterworth Press, 1953); E. Mountevans, *From Husky to Sno-Cat. A Short Survey of Polar Exploration Yesterday and Today* (London: Staples Press, 1957); J.E. Caswell, *Arctic Frontiers: United States Exploring Expeditions in the Far North* (Norman: University of Oklahoma Press, 1956); L.P. Kirwan, *The White Road: A Survey of Polar Exploration* (London: Hollis & Carter, 1959).

97. N. Cull, *The Cold War and the U.S. Information Agency: American Propaganda and Public Diplomacy, 1945-1989* (New York: Cambridge University Press, 2008).

From Colonialism to Environmentalism: Towards a Conclusion

The Cold War pushed the Arctic into the centre of geopolitical interest. Immediately, Greenland was subject to massive but restricted and controlled military colonization and exploitation by U.S. forces. Denmark, maintaining territorial sovereignty, was the controlling power, but at the same time it was forced and willing to accept what Krige described as “consensual hegemony” by the USA. Greenland is a particularly interesting case of U.S. hegemony.⁹⁸ First, it involved a massive physical military presence and activity, including projects like the construction of a nuclear reactor under the ice. No scientific or technological endeavour in post-war Western Europe came close to such massive U.S. intervention. Second, science and technology supported by U.S. institutions not only played a role as mediators of American interests and values in the reconstruction of post-war science in Western European countries, but science and technology also became crucial assets for gaining knowledge about and controlling the Arctic territory. Science prepared for and helped achieve U.S. colonial interests in Greenland.

The presence of the U.S. Army on Greenland represented post-war colonialism in multiple ways. The local population had to give way to American rule at specific locations like Thule. The U.S. Army was not specifically interested in the indigenous population and culture. It didn't fight with Inuit, it didn't administrate Inuit settlements, and it didn't systematically interfere in Inuit culture. The military bases rather represented a small but powerful and isolated state of its own within the vast territory of Greenland. More important was coordination and agreement with the colonial power Denmark, which accepted, profited from, and accommodated to U.S. military colonialism in Greenland. Denmark may not have had much of an alternative. But, similar to the American influence and presence in Western Europe, this much stronger form of colonial endeavour was accomplished through consensus with the Danish government and authorities.

Science and technology played crucial parts in this power game and became means to pursue geopolitical interests in a very direct sense. Control and power in the Arctic regions required new scientific knowledge. Military operations, such as mobility, construction, communication, energy supply, maintenance, reconnaissance, and intelligence, represented totally new challenges in the Arctic environment compared to operations in known terrain and more moderate climates. Science therefore became an integral part of military operation. Furthermore, it

98. Krige, *American Hegemony*, 5.

served as a vehicle of transnational cooperation (with Denmark) and justification (to the local population and the wider public). The military interest in the science and technology in Greenland had a significant impact on the relevant scientific fields and disciplines. Arctic geophysical sciences and nuclear technology thrived. At the same time, these fields had to accommodate to military rules and culture, such as limited autonomy and strict classification measures. The U.S. military colonized the realm of these sciences, defined significant scientific problems and controlled scientific work.

U.S. territorial, political, and scientific colonialism in Greenland worked and prospered under geopolitical conditions of the Cold War, particularly at the height of international tensions in the 1950s and 60s. The colonial endeavour was largely “consensual” with Denmark as well as with the community of scientists, based on a common understanding of military threats and the role of the superpower USA in the Cold War and based on considerable financial rewards (in terms of research contracts).

Most historical studies portray post-war science as shaped by a largely coherent context of Cold War politics which laid the ground, shaped the structures, and paved the way for Cold War science as well as post-Cold War science. The Cold War context, however, was subject to change itself. While it proved predominant in the 1950s and 1960s, new contexts and motivations, notably environmentalism, have received much increased attention since the 1970s. Environmental change in the Arctic caused the Pentagon concern already by the late 1940s, when it became obvious that Arctic glaciers had lost size due to a warmer climate. Environmental interests began to play an increasingly predominant role in research efforts in Greenland particularly after 1970. Efforts in Arctic environmental research, such as glaciology and climate research, expanded considerably in the last two decades of the Cold War period. To a large degree they built on research efforts and infrastructures provided and supported by military ventures.

With regard to the impact of environmental concern on post-war science and technology, we are on less familiar ground. It is an open and as yet hardly investigated question to what extent environmental concern opened up new perspectives and contributed to shaping or reshaping research activities in the post-war period.⁹⁹ Greenland represents an interesting

99. F. Buell, *From Apocalypse To Way Of Life: Environmental Crisis In The American Century* (New York: Routledge, 2003); P.R. Josephson, *Resources Under Regimes: Technology, Environment, and the State*, *New Histories of Science, Technology, and Medicine* (Cambridge, MA: Harvard University Press, 2006); S. Yearley, “Nature and the Environment in Science and Technology Studies,” in *The Handbook of Science and Technology Studies*, eds. E. Hackett, and al. (Cambridge, MA: MIT Press, 2007), 921-48.

case. Military research activities in Greenland strongly affected the Arctic environment. At the same time, Greenland has a very sensitive environment, which was prone to being affected by global environmental change. It is as yet unclear what impact the rise of environmental concern among scientists, politicians, and the general public had on research efforts in Greenland, in which fields and when. Also repercussions from the ongoing military research activities are largely unknown. Some authors suspected that by ceding military funding scientists increasingly turned to environmental questions. Oceanography or ionospheric research may be proper examples.¹⁰⁰ This may be an acceptable interpretation on a very broad scale. But it would be too simple to stick to such a sequential picture. In many instances, military and environmental concern and related research efforts coexisted at the same time, as in fields like climate research or glaciology.

Little is known however about the periods when predominant contexts and motivations shifted, such as the transition from science in the Cold War realm to science in the era of environmentalism. How did environmentalist scientists perceive military science and how did the administrators of military science respond to the challenges of environmentalism? To what extent did environmental interests profit from military endeavours and coexist with them peacefully, and to what extent did confrontations emerge? Military commanders had various options for coping with environmental demands, first by re-interpreting military research activities in the light of environmental concern, second by reshaping activities to accommodate environmental interests and, third, by expanding research activities in new environmentally-relevant research fields. To what extent, when, and in what ways did research planners take environmental interests into consideration? Can we observe shifts of perspective, changing narratives of presenting and interpreting research results, or even significant transformations of research activities? To what extent can military interest and environmental concern be described by coexistence, coordination, or confrontation? The history of geophysical research efforts in Greenland provides ample opportunities for exploring questions like these. Also, here, simple and general answers appear less likely than a complex pattern of findings for different periods and research fields.

100. N. Oreskes, "A Context of Motivation: US Navy Oceanographic Research and the Discovery of Sea-Floor Hydrothermal Vents," *Social Studies of Science* 33, 5 (2003): 697-742; Hamblin, *Oceanographers*, xvii-xxix.